DATA POLICY CONSIDERATIONS FOR JOINT COMMERCIAL-GOVERNMENTAL REMOTE SENSING RADAR MISSIONS

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Abstract

NASA has proposed a next-generation spaceborne imaging radar mission, known as LightSAR, as an innovative public sector/private sector partnership. The baseline mission design calls for industry to partner with NASA to develop and operate an L-band, quad-polarization, multi-mode imaging radar remote sensing satellite. One of the main considerations for structuring the partnership is allocation of data acquisition and distribution rights to satisfy both science needs and commercially viable operations. Commercial interests lie in the high-resolution, quick-turnaround data sets, whereas science requirements call for lower image resolution data with multiple polarizations. Unlike optical remote sensing systems, the characteristics of the imaging radar system allow for a unique method of balancing commercial and science needs by allocation of tasking rights based on image resolution and data type. Data distribution rights could also be allocated in a similar fashion.

Introduction

LightSAR is a proposed NASA program to develop and operate a next-generation imaging radar satellite under an innovative federal-commercial partnership. The reference mission (JPL, 1999) calls for an L-band radar that provides multiple operating modes, including 3 m high-resolution spotlight, repeat-pass interferometry, and wide-area scanSAR. Figure 1 shows a design concept for data acquisition modes.

As part of the pre-phase-A development process, a workshop was held from 27-29 August 1996, to bring together interested parties to develop a mission concept (JPL, 1996). Prospective commercial partners, science and commercial users, and government agencies participated. The results of the workshop led NASA to fund a study contract in January 1997 for four industry teams to develop a comprehensive development and operational plan for a LightSAR mission (JPL, 1999).

The workshop and studies showed that most of the non-science users would be interested in high-resolution (sub-5 m) data with a rapid revisit/acquisition capability. Moreover, these prospective users would best be served by a value-added provider that was able to convert the radar imagery into a form that could be used in a Geographic Information System (GIS) database or was comparable to optical imagery (i.e. – a LANDSAT or SPOT image). Most science users were interested in medium-resolution (25 m) data and interferometry. Science users would also have the resources and desire to utilize relatively unprocessed data sets (raw L0R signal data or uncorrected L1A imagery).

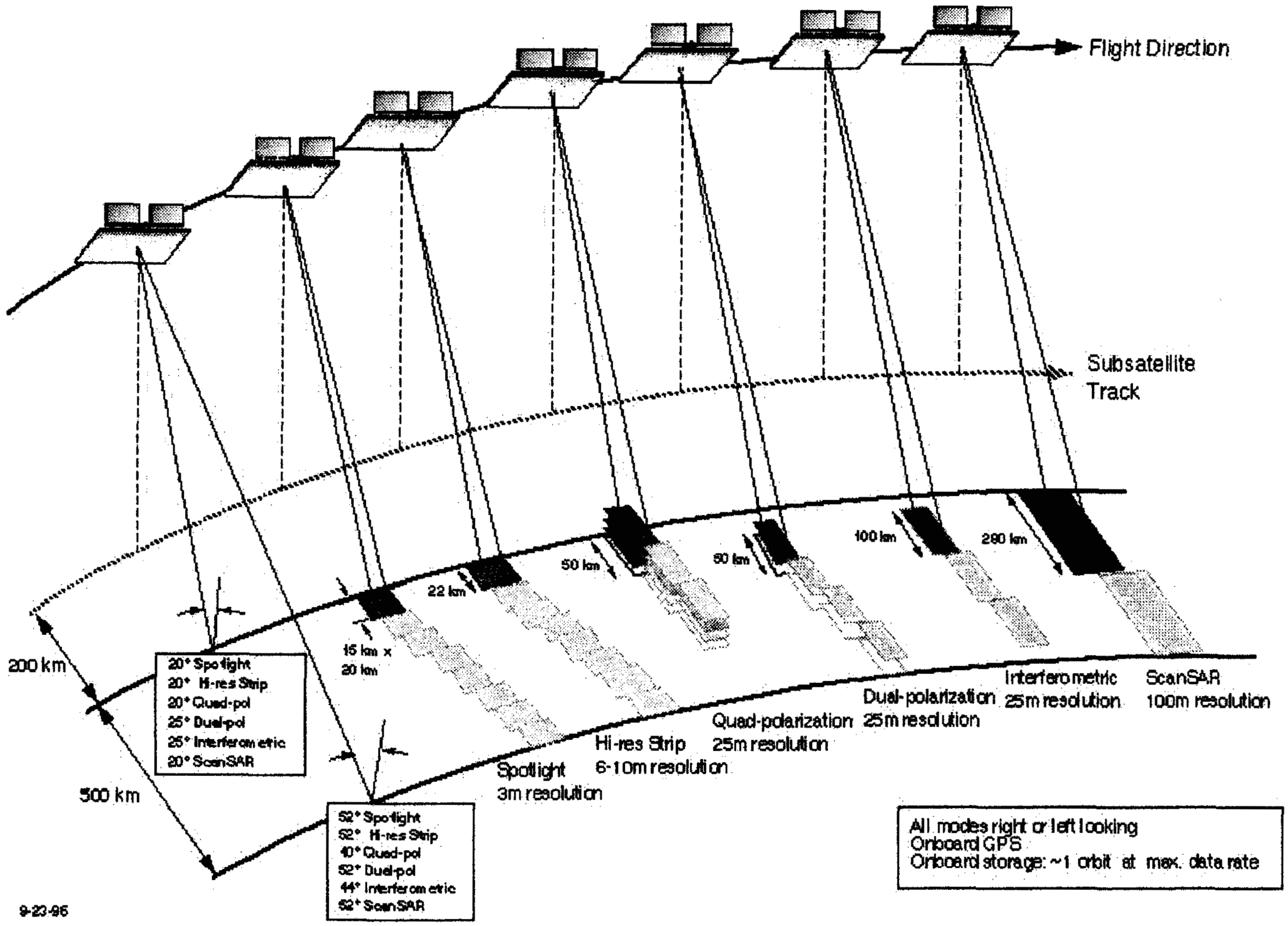

Figure 1: Proposed LightSAR Data Acquisition Modes

Overview of Radar Remote Sensing

In order to understand the differences between optical and radar remote sensing, a discussion of the mission design constraints and radar processing technology is required. A radar instrument is an active device, sending out pulses of radio wave or microwave energy that are reflected back into a receiver. An optical system relies on reflected solar illumination (in the case of visible and near-IR) or emitted thermal radiation (longwave IR). Thus, a radar system can operate equally well during day-lit or nighttime portions of an orbit, whereas most optical systems only acquire data during the day-lit periods.

Radar imagery also looks significantly different from color-IR optical images, as the radar is "seeing" a return based on the amount of transmitted energy reflected back in the direction of the receiver. This return is a measure of the interaction between the size (wavelength) of the radar pulse and the roughness of the Earth's surface. A comparison of a LANDSAT TM (Thematic Mapper) image of the San Francisco Bay area with a radar image of the same area from SIR-C (Spaceborne Imaging Radar-C) is shown in figure 2.

Another major difference between a radar image and an optical image is that radar images need to be processed (correlated) before a recognizable image of the target area can be seen. Figure 3 compares a raw L0R signal data image with the correlated L1 radar image. Figure 4 shows a simulated LANDSAT 7 L0R image. Note that the L0R LANDSAT image is recognizable as an image and could be used for some analysis, whereas the radar image requires processing to generate a usable image. In general, the processing power required to generate a L1 radar image from raw L0 signal data is an order of magnitude greater than that required to apply geometric and radiometric corrections to an optical image.

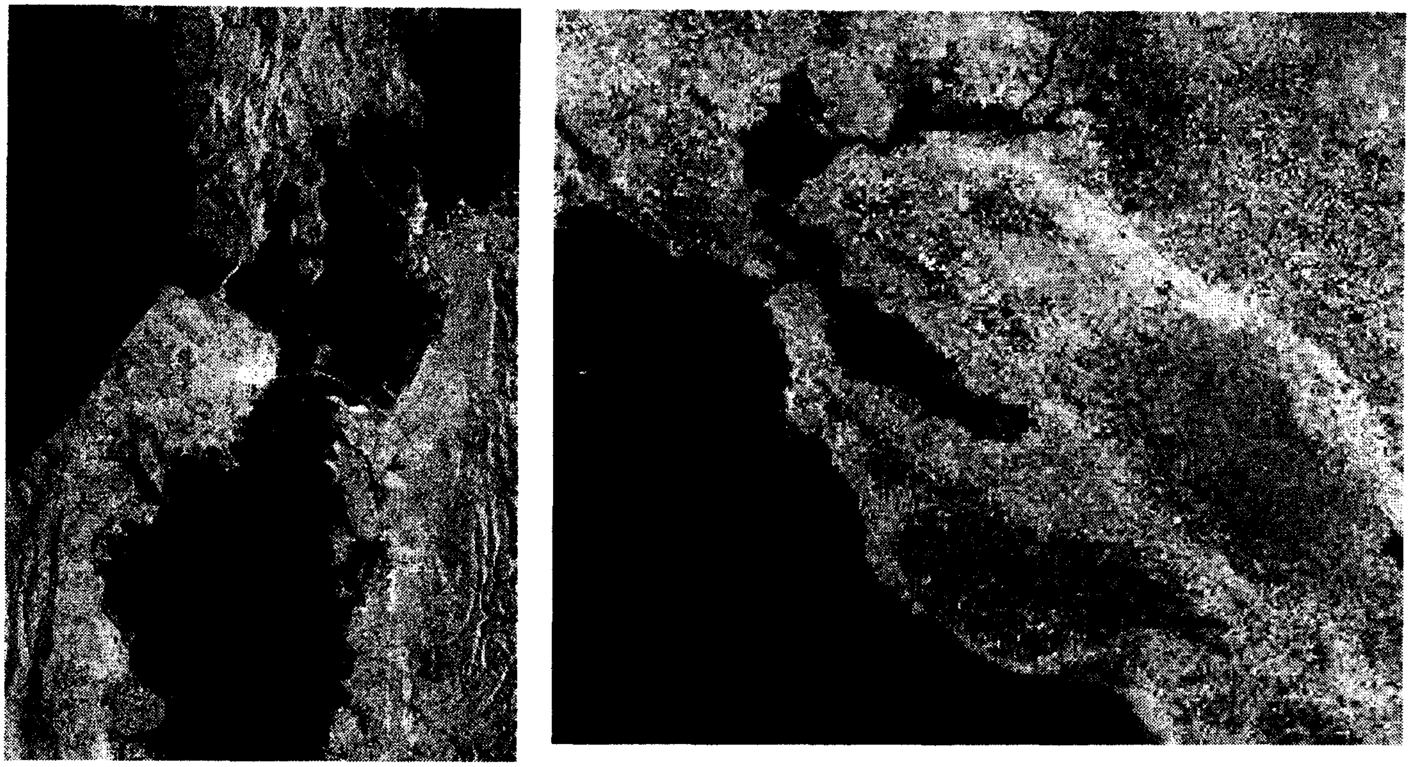

Figure 2: San Francisco Bay Area Imaged by SIR-C (Left Image) and LANDSAT TM (Right Image)

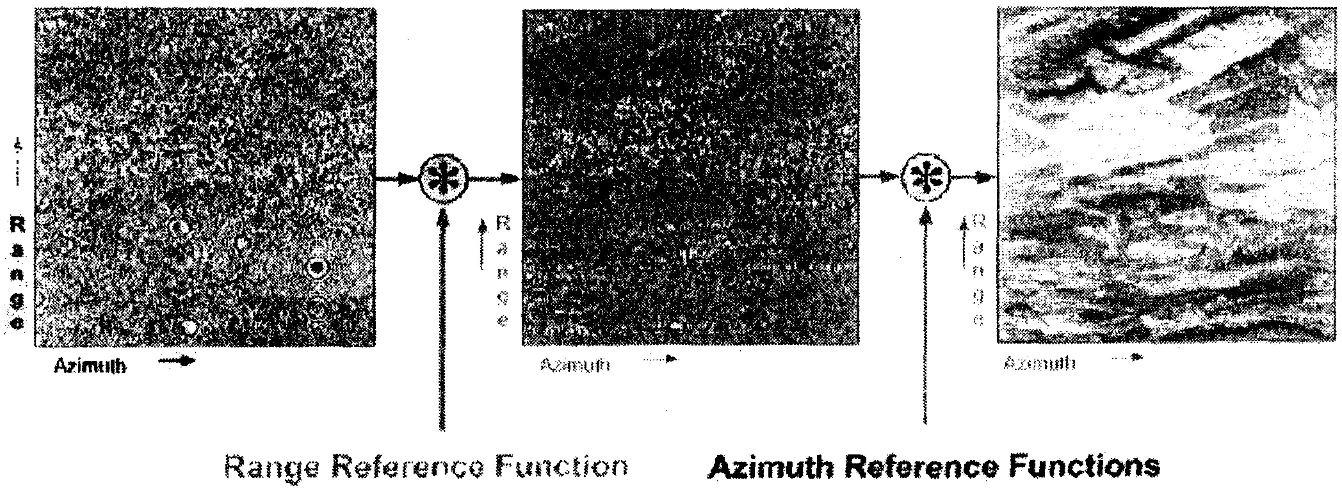

Figure 3: Raw (Left and Center Images) and Processed (Right Image) SAR Image

In addition to the differences between the two data types, the mission and sensor design yield different tradeoffs. As an active system, a radar instrument requires significant amounts of spacecraft power in order to meet resolution and signal-to-noise ratio requirements. In an optical system these requirements are a function of detector technology and aperture size, whereas a radar system adds the transmitter as an additional variable to be taken into consideration in the design process. In order to achieve a reasonable system configuration, a radar satellite will use solar panels to charge a battery subsystem that provides for a limited "on-time" during each orbit. This limits the amount of coverage a satellite can provide on any give orbit, and requires development of a tasking system to prioritize acquisitions. For a multi-mode radar, there is the added dimension of balancing satellite resources (i.e. – power, onboard data storage capacity) with the requirements of each acquisition mode.


Figure 4: Comparison Between LANDSAT 7 L0R (Left Image) and L1 (Right Image)

An Equitable Data Policy

Based on the two major differences between optical and radar sensors, the requirement for processing to develop an image and system tasking to use limited resources, an equitable data policy can be developed that balances the desires of the general science user community with the requirements of a commercial partner. The separation of resolution requirements between the science (medium-resolution) and commercial (high-resolution) user community also plays a large role in the development of the data policy. The data policy covers data acquisition rights, L0 (raw signal) data distribution and archiving, and L1 (image) data processing and distribution.

The baseline mission would the commercial partner operate the satellite. System resources (sensor on-time or percentage of acquired scenes/data) will be allocated between NASA and the commercial partner. The commercial partner will have the primary responsibility for generating L1 (image) products for distribution, although the government may retain a limited L1 processing capability. The L1 processing system operated by the government will be used for data quality assessment and internal research purposes, with no provisions for redistribution of L1 products.

Data Acquisition

Data acquisition defines what data types can be acquired by the government and commercial partner, how tasking rights are assigned, and provisions for archive disposition at the end of the mission. Data acquisition plans include:

- Satellite resources shared, allocated between commercial partner and NASA
- NASA allocation only covers acquisition of medium-resolution data (i.e. – 25 m, ScanSAR, or repeat-pass interferometry)
- Commercial partner acquisitions can be any data type - both high-resolution or medium resolution for commercial resale
- NASA PI request for high-resolution data handled by commercial partner at preferred "NASA rate"
- NASA allocation only taskable by NASA PIs
- Satellite Land Remote Sensing Act provisions apply – all raw L0 data is in public domain, distribution rights for commercial partner allocation transfer to public domain after a negotiated "Proprietary Period"
- Preemptive tasking in support of disaster response or national security
- Conflict resolution

L0 Data Policy

L0 data policy covers the archival and distribution of the raw L0 signal data by the government and commercial partner.

- NASA-acquired L0 data distributed at cost of fulfilling user requests (COFUR)
- All NASA-acquired L0 data immediately in public domain

- L0 data format same for distribution and L1 processor input
- Commercial partner L0 data distribution at prevailing market rates set by commercial partner
- High-resolution data purchased by NASA PIs from commercial partner redistributable under negotiated redistribution rights (both PI acquisitions and purchases of commercial acquisitions)
- Metadata for all L0 data, both NASA and commercial, ingested into government database
- Government database identifies commercial partner scenes and provides ordering contact information

L1 Data Policy

L1 data policy covers the processing of raw L0 signal data into L1 image products.

- Commercial partner has primary responsibility for L1 processing
- All L1 data process-on-demand
- L1 data not archived
- Commercial partner transfers L1 processing capability to government at end of mission
- No public redistribution of L1 data by government during mission
- L1 processing procedure/dataflow of NASA acquisitions same for general public and NASA
- Commercial partner charges NASA PIs preferred "NASA Rate" for L1 processing of NASA acquisitions
- Commercial partner may license/sell L1 processing systems or software (non-exclusively)
- Government database provides linkage to commercial partner for L1 processing requests

An Example of an Operational Implementation

Figure 5 shows an example of an operational system that implements this data policy. The radar satellite has been jointly developed by NASA and a commercial partner. In exchange for their portion of development effort, NASA has been given rights to 70% of the system capacity, based upon radar on-time. Both the government and the commercial partner operate L0 archives for their portions of the acquired data. Additionally, the commercial partner operates a L1 processing system at their archive facility. In addition to L0 and L1 data sales, the commercial partner is allied with a number of value-added providers that use the L0 and L1 data to generate higher-level products (i.e. – GIS layers, classification maps, DEMs, etc.). The commercial partner has a copy of the metadata for the NASA-acquired data, for which they can broker sales of L0 data or L1 processing.

Analysis of Proposed Data Policy

This data policy provides both the commercial partner and the government with the potential to achieve the bulk of their objectives. The results from the workshop indicated that most of the commercial sales were in higher-resolution (5 m or better) and value-added products. Higher-resolution products compliment the products from the proposed commercial (optical) remote sensing satellites and could be marketed in a similar fashion. Moreover, radar data can be acquired at night and through clouds. Thus, restricting the higher-resolution modes to the commercial partner protects what they perceive as their primary revenue source.

Most of the traditional commercial remote sensing data users are only familiar with optical systems (i.e. - LANDSAT, SPOT, aerial photography) and would need either education and tools to effectively use radar data, or require the services of a value-added provider to convert the radar data into a more familiar form such as a GIS layer or classification map. Restriction of processing and distribution of L1 and higher data products addresses this revenue stream and enables a significant participation by value-added providers and vendors of remote sensing tools (i.e. - data visualization, analysis, data fusion, etc.). The provision of negotiated redistribution rights for government-purchased L1 products draws upon an existing precedent and allows the science community access to the data at a reasonable cost.

The science community is most interested in lower-level data products, in sufficient volume and coverage to address their particular research objectives. There isn't a current science rationale for large volumes of high-resolution data, and 25 m data will address many current research program requirements. Repeat-pass interferometry is also a high priority data acquisition objective, but a 25 m resolution is adequate for the proposed monitoring program that would be the main user of most interferometry acquisitions (JPL, 1998).

Radar satellite acquisitions will require satellite tasking to efficiently use the limited on-time per orbit, unlike wide-area- or continuous-coverage satellite systems (such as AVHRR or LANDSAT). Wide-area- or continuous-coverage satellite systems also generate large volumes of data and it is likely that a desired scene has been or will be acquired without any specific tasking. By restricting LightSAR tasking rights to NASA PIs and the commercial partner, the NASA science community can acquire their targets and build a publicly-accessible archive. While this archive will have a significant number of scenes, it is less likely that a commercial user will be able to find a desired scene based on the science research tasking rationale. Moreover, the government archive will contain predominantly medium-resolution scenes. Allocating tasking rights for the general public to the commercial partner allows the partner to offer exclusive tasking rights to other, non-NASA, users. This will enable the commercial partner to provide - data acquisition, on demand, for a user's target. Thus, the policy balances the government's desire to generate a publicly-accessible archive with the commercial partner's desire to offer a service that will attract customers instead of ordering a cheaper scene from the government archive.

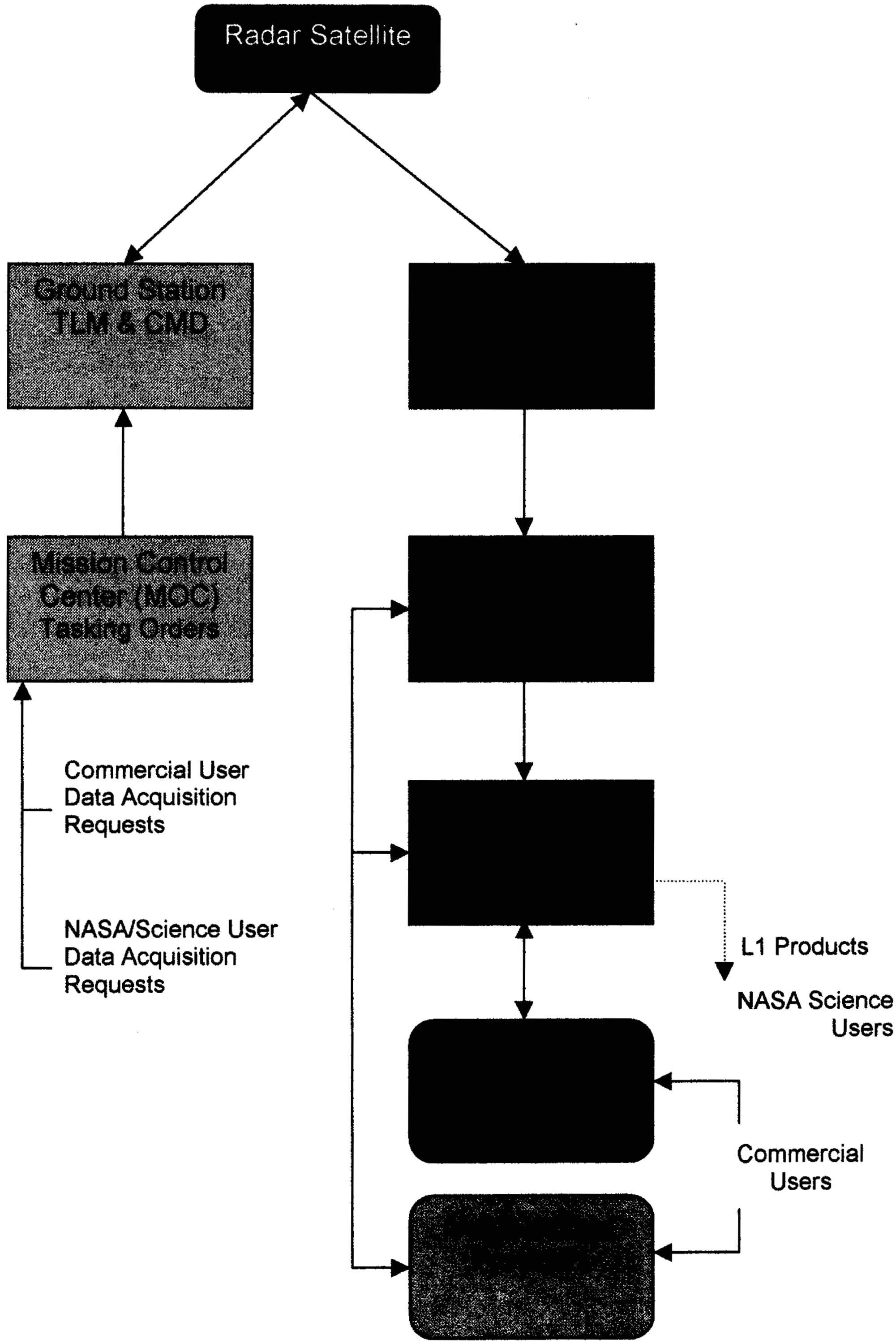

Figure 5: Operational System Example

Limitation of operational L1 and higher processing to the commercial partner allows for the science community to process their own data (perhaps using tools developed or licensed by the commercial partner), while directing the less-sophisticated general user to the commercial partner. Having all L1 processing on-demand enables the commercial partner to make money on repeat data sales, without the risk of competing with a L1 archive for data sales. This balances the desires of the science community with the requirement of the commercial partner to generate revenue from processing operations.

Conclusions

The unique characteristics of radar remote sensing systems lend them to an equitable data policy that satisfies the objectives of both the government and commercial partner in a jointly developed and operated system. The data policy allows the commercial partner to pursue revenue-generating operations for the bulk of articulated user requirements, while enabling the government to acquire substantial quantities of data for scientific research. While primarily envisioned for use with a system jointly developed and operated, the data policy is equally applicable to a system developed primarily by the commercial partner where government participation is represented as a "data-buy" customer.

References:

JPL, 1996: Workshop Summary, Applications of Future US Spaceborne Imaging Radar Missions, JPL D-13928, October 1996

JPL, 1998: LightSAR Science Requirements, JPL Internal Document D-13945, March 1998

JPL, 1999: Technical Summary of LightSAR Mission Design
http://lightsar.jpl.nasa.gov/lightsar/mission.htm

JPL, 1999: Recent LightSAR Press Releases
http://lightsar.jpl.nasa.gov/lightsar/news.htm

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